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Public Health Service ● Environmental Health Service

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INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 11, Number 4, April 1970

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service
Bureau of Radiological Health

Reports

An Investigation of X Radiation from Color Television Receivers in Suffolk County, New York

Seymour Becker[1]

The results of an investigation of color television receivers at the homes of 6,482 residents in Suffolk County, who requested a radiation inspection after publication of the proposed study in the newspapers, is presented.

The survey consisted of two parts:

1. an investigation of only General Electric color television sets from July 1967 through August 1967; and
2. a radiation inspection of General Electric and 39 other types of television receivers requested by owners from January 1968 to December 31, 1969.

X-radiation emissions were detected in 37 of the 40 name brands of color television sets checked. Over 1,000 (16.2 percent) color television sets emitted x radiation above the NCRP recommended guides. The x-ray emissions ranged above 0.5 mR/h to 150 mR/h at 5 cm from the television set.

X-radiation emissions were reduced to the natural background of the home by adequate modification and adjustment of the television components.

During the summer of 1967, the Surgeon General's office of the United States Public Health Service issued a public statement that General Electric (G.E.) color television receivers were suspected of emitting x radiation at levels higher than desirable.

As a result, an investigation by the Suffolk County Department of Health (SCDH) was commenced in Suffolk County to locate the G.E. color television sets. At the time of the inspection a spot check of other television manufacturers' sets was conducted. It was found that other brand-name color television receivers also emitted levels of x radiation above the recommendations of the National Council on Radiation Protection and Measurements (NCRP).

In 1959, the NCRP had released a statement concerning x rays produced in home television receivers. In part the statement reads:

> "To insure that the television contribution to the population gonad dose will only be a small fraction of that due to natural background radiation, the NCRP recommends that the exposure dose rate at any readily accessible point 5 cm from the surface of any home television receiver shall not exceed 0.5 mR/hr [sic] under normal operating conditions."

Due to a limited staff at the SCDH, priority was given to inspection of G.E. color television sets only. With the cooperation of representatives from the G.E. regional office in Suffolk County, the investigation revealed that 87 of the nearly 500 G.E. color television sets checked required modification for compliance with the NCRP guidelines. Since the percentage of noncomplying G.E. color TV receivers was significant (17.4 percent), the Commissioner of Health, as well as the Director of the Division on Environmental Health, decided that, as a service to Suffolk County residents, the color television set survey should continue and include all makes of color television sets.

Description of survey

In order to facilitate locating the color television sets in Suffolk County, a press release was sent to all local daily and weekly newspapers and to radio stations. A statement was made that any owner of a color television set should contact the SCDH. Within the first weeks of the public announcement, approximately 3,000 requests by telephone and mail were received from Suffolk County resi-

[1] Mr. Becker is chief, Radiation Control Unit, Division of Environmental Health, Suffolk County Department of Health, Riverhead, N.Y.

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dents and from residents of neighboring areas (Nassau County, New York City, and Westchester County). Calls from outside Suffolk County were referred to the Department of Health having jurisdiction.

Representatives from the Bureau of Radiological Health (BRH) of the U.S. Public Health Service (PHS) visited the Suffolk County Department of Health at the request of SCDH to determine if the detecting instruments used were consistent with those of the PHS. A random survey was made throughout the county, and the representatives acknowledged that the detecting instruments used by the local health unit (Victoreen 440 R.F. and Victoreen G.M. counter-open-window probe 1B85) were suitable for the detection of low energy x radiation.

The requests from Suffolk County television set owners were listed by towns (there are ten towns in the county) in order to simplify the scheduling of inspections. Commencing in January 1968, a visit to each television set owner who had requested inspection of his set was arranged. A telephone call was made on a day-by-day schedule by the SCDH to the television set owner listed for an appointment. Initially, an average of 18 visits was made daily, decreasing as requests for this service tapered off. At each inspection, the owner of the television set was requested to turn the set on, move the set if necessary to facilitate testing and upon completion of the inspection, turn the set off. The detecting probe scanned the television cabinet approximately 5 cm from the surface of all accessible areas (including under the set). When the detecting instrument indicated net readings of 0.5 mR/h or above, the owner of the television set was informed. Any discussion of possible radiation hazards was discouraged since the function of the survey was to find out if the television set was in compliance with the NCRP recommendations. However, as a precautionary measure, in accordance with PHS recommendations, a suggestion was made to the television set owner to see that he and his family sit at least 6 feet from the sides or front of the set when viewing television programs.

The manufacturer or a local television serviceman was then notified of the significant findings by a representative of the SCDH or the owner of the television set. Generally, an authorized or independent television serviceman or the manufacturer's representative, accompanied by an electronics engineer, was dispatched to service the set. When the cause of the x-radiation emissions was determined and corrected, the detecting equipment on a resurvey would indicate levels of radiation at natural background.

As of December 31, 1969, 6,482 color television sets had been inspected (table 1). Approximately 16.2 percent of the receivers checked were found to be emitting x radiation above the NCRP recommendations.

The general causes of the x-radiation emissions from a color television set were:

1. manual manipulation of the high voltage control on the high voltage shunt regulator tube;
2. anode and cathode components of the high voltage shunt regulator tube not properly aligned,
3. replacement of a high voltage shunt regulator tube with another unaligned tube by the television serviceman. On most initial inspections and on re-inspections by representatives of the SCDH, it was learned from the television serviceman that he did not use a voltmeter. Therefore, he would automatically replace the high voltage shunt regulator tube. In some revisits, the investigators found a higher x-radiation leakage after the service adjustments had been made. Further investigation revealed that in most cases a faulty 6BK4 high voltage shunt regulator tube had been installed by the television serviceman;
4. defective high voltage rectifier tube;
5. circuit failure caused by a breakdown of the capacitor in the high voltage regulator component;
6. defective resistor component which caused the high voltage regulator to function improperly;
7. connector to the high voltage shunt regulator tube's positive terminal not affixed properly;
8. defective power transformer causing malfunction of other components which emitted x rays;
9. high voltage cage not grounded causing malfunction of other components;
10. ground strap on yoke of picture tube not installed properly causing malfunction of other components;
11. increase of outside line voltage;
12. cathode-ray tube lacking adequate shielding;
13. shielding on the high voltage cage not installed;
14. failure of serviceman to meter and adjust the high voltage upon installation of the sets in the consumer's home; and

Table 1. Results of color television receiver inspections

Color television receiver (brand or manufacturer)	Number of television receivers with an exposure rate before corrections at 5 cm from surface of television set of:[a]					
	≤0.5 mR/h	>0.5–<1.0 mR/h	1.0–<10.0 mR/h	10–<16 mR/h	≥16 mR/h	Total
Admiral	430	62	58	2	1	553
Ambassador (Emerson)	4	3	2			9
A.M.C. (A&S)	5	2	1			8
Andrea	22	3	2			27
Arvin	2	1	0			3
Clairtone	18	2	1			21
Cornelia	1	0	0			1
Curtis Mathes	33	3	5			41
Delmonico	11	3	6			20
Dumont	19	5	1			25
Emerson	56	3	6			65
General Electric	433	43	47	4	1	528
Grants Bradford	53	11	9	2	2	77
Heathkit	30	3	1			34
Hitachi	6	1	0			7
Hoffman	1	0	0		1	2
JVC	1	0	0			1
Macy's Supre–Macy	11	7	7			25
Magnavox	526	52	26	2	5	611
Montgomery Ward Airline	22	2	9			33
Motorola	221	29	23	1		274
Muntz	2	1	0			3
Olympic	41	2	4			47
Packard Bell	3	1	1			5
Panasonic	25	4	1			30
Penny's Penncrest	29	2	7			38
Philco	221	7	10			238
RCA	1,459	116	55	7	1	1,637
Sears/Japanese	70	11	18			99
Sears/Silvertone	202	15	6			223
Setchell Carlson	12	8	5	2		27
Sharp	5	1	0			6
Singer	2	0	0			2
Sylvania	441	37	8			486
Symphonic	2	1	0			3
Telefunken	2	1	0			3
Truetone (Spiegel)	2	1	0			3
Toshiba	10	1	1			12
Westinghouse	34	2	8			44
Zenith	963	116	123	7	2	1,211
Grand total	5,429	562	451	27	13	6,482

[a] 16.2 percent of television receivers were above the recommended NCRP guidelines as of December 31, 1969.

15. the three color electron guns not operating independently of each other. X radiation had been detected when the colors were faded out and more white than other colors was visible at the viewing area.

During the initial phase of the investigation, a record was kept of the model number, date of purchase, size of screen, and type of cabinet (wood or metal) of each receiver. Shortly after the investigation began, this procedure was terminated because x radiation had been detected beyond the measured distance recommended by the NCRP guidelines regardless of model, age of set, screen size, or type of cabinet, if any of the previously listed causes were present.

If the high voltage was determined by the serviceman to be above 30,000 volts, x radiation was detected emanating from various parts of the television set, front, top, back, sides, and underneath. On most of the television receivers producing exposure rates above 10 mR/h at 3 to 6 inches from the receiver surface the TV serviceman reported high voltage readings above 30,000 volts.

At the request of an Air Force Base, a spot check was made on television sets on the base that had been purchased outside Suffolk County. The investigation of these sets revealed causes of x ray emission similar to those found in television sets purchased in Suffolk County.

Summary

Representatives of the Suffolk County Department of Health visited homes of 6,482 owners of color television sets in the county. X-radiation emissions were detected in 37 of 40 name brands of color television sets checked. Over 1,000 (16.2 percent) color television sets emitted x radiation above the NCRP recommended guidelines. The x-ray emissions ranged above 0.5 mR/h to 150 mR/h at 5 cm from the television set. Five hundred and sixty-two color television sets emitted x rays above 0.5 to less than 1.0 mR/h, 451 color television sets emitted x rays from 1.0 to less than 10.0 mR/h, 27 color television sets emitted x rays from 10 mR/h to less than 16 mR/h, and 13 color television sets emitted x rays in the

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range of 16 mR/h to 150 mR/h. Those color television sets that emitted x radiation above 10 mR/h at 5 cm were observed to have a high voltage of more than 30,000 volts on a calibrated voltmeter.

The outstanding causes of x-ray emissions were improper adjustments of the high voltage control which caused the voltage to exceed the factory specifications, faulty high voltage shunt regulator tube, and replacement of one faulty high voltage shunt regulator tube with another faulty one by the television serviceman. X-radiation emissions were reduced to the natural background of the home by adequate modification and adjustment of the television components.

Acknowledgment

The writer wishes to express his appreciation for the encouragement and assistance received throughout the entire investigation to Dr. G. H. Leone, Commissioner; Mr. H. W. Davids, Director, Division of Environmnetal Health of the Suffolk County Department of Health; Mr. D. Smith, Mr. S. Harris, and Mr. R. H. Schneider of the U.S. Public Health Service, Bureau of Radiological Health; and Mr. H. Farkas, Associate Engineer of the Bureau of Radiological Health, New York State Health Department.

Strontium-90 in Human Bones in the United States, 1962–1966

E. J. Baratta, E. S. Ferri,[1] and *M. A. Wall*[2]

The Bureau of Radiological Health has been conducting a continuous investigation of strontium-90 in human bones since late 1961. Autopsy specimens, mostly vertebrae, were collected by pathologists, medical examiners, and coroners in selected areas throughout the United States. The population of interest consisted of children and young adults up to 25 years of age. Samples were collected from areas around six principal cities: Atlanta, Boston, Cincinnati, Los Angeles, New Orleans, and Seattle.

From 1962 through 1966, over 1,600 specimens have been analyzed. The specimens were grouped and analyzed according to age and year of death. A review of the data shows that peak strontium-90 levels occurred in most age groups during the years 1963 and 1964. Decreasing values approaching those of 1962 are shown in analyses for 1966. A histogram of the frequency distribution for 1966 displays a slightly positive skewness which, when plotted, indicates a log normal distribution consistent with earlier observations on biological specimens.

Since late 1961, the Bureau of Radiological Health has conducted a program for the determination of strontium-90 in human bones (*1-4*) similar to the one previously conducted by Kulp (*5*) in 1961. The population from which bone samples are obtained is composed of individuals under 25 years of age, thereby including the age group whose bones are being formed at the fastest rate. This report summarizes the data for 1962 through 1966. The specimens are normally obtained from accident victims, but some are selected from those who have died from other causes. All specimens are selected to exclude those whose history reflected a calcium deficiency.

The samples are collected principally from areas around six cities: Atlanta, Ga.; Boston, Mass.; Cincinnati, Ohio; Los Angeles, Calif.; New Orleans, La.; and Seattle, Wash. (figure 1). The areas also include other cities and towns in the United States. Over 1,600 bone specimens collected from 1962 through 1966 have been analyzed.

Samples normally collected are vertebrae or ribs as these specimen types are readily obtainable on autopsy. Specimen collection is made possible through the cooperative efforts of pathologists in various hospitals throughout the country.

Analysis

Prior to 1963, the samples were analyzed by a procedure similar to Volchok's (*6*). Since 1963, the analytical methods used are those presented by Baratta and Ferri (*7*) and Magno, Baratta, and Ferri (*8*). A number of human bone samples were analyzed by both methods, and an analysis of variance of the data showed no significant difference between the results of the two methods.

For purposes of maintaining analytical quality control "blind" duplicate analyses are performed on 10 to 20 percent of the samples. In addition, "spiked" synthetic bone ash samples are analyzed routinely. A cross check program with the Health and Safety Laboratory of the Atomic Energy Commission was conducted monthly. Results for this program over the past 2 years show satisfactory agreement between the two laboratories.

Discussion

Table 1 lists the levels of strontium-90 in human bone in pCi ^{90}Sr/g Ca for the years 1962 through 1966. The age groups are broken into 0-5 months, 1 year, 2, 3, 4, 0-4, 5-9, 10-14, and so forth. The data indicate that the levels of ^{90}Sr/Ca in pCi/g in most of the age groups reached a peak in 1963 to 1964. This was expected, since strontium-90 in fallout from above ground nuclear tests of 1961 and 1962 reached its peak in air and milk in 1963 and 1964.

[1] Northeastern Radiological Health Laboratory, Winchester, Mass. 01890.

[2] Mrs. Wall is now with the Materials Research Command, U.S. Army, Natick, Mass.

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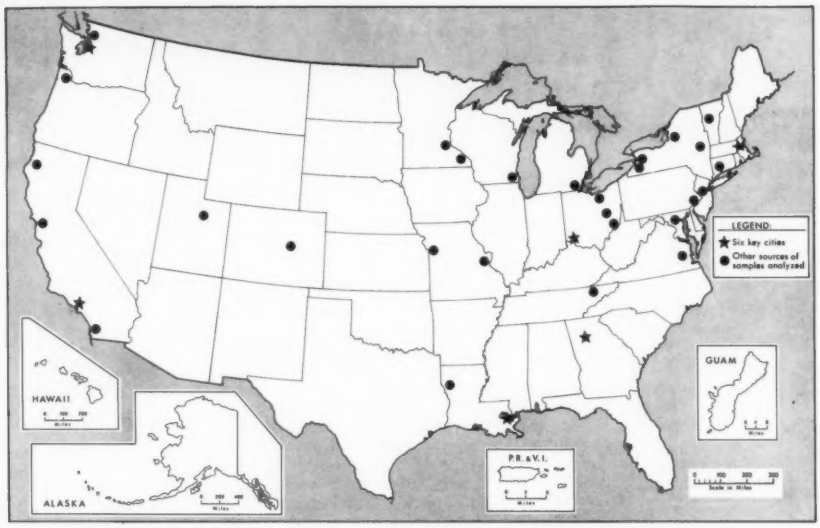

Figure 1. Human bone sampling locations

The median strontium-90 to calcium ratio plotted against age and year of collection is shown in figure 2. It can be noted that, in general, the strontium-90 to calcium ratios for bones collected in 1966 approached the levels found in bones collected in 1962. The strontium-90 to calcium ratio found in bones of the 0-4 year age group collected in 1966 is approximately the same as the levels found in bones collected in 1965, with the exception of the 2-year-old children. The 1963 and 1964 ratios of strontium-90 to calcium appear to be similar to each other for all age groups. Also similar are the strontium-90 to calcium ratios for 1965 and 1966, with the exception of the already noted difference. The strontium-90 to calcium ratios for bones collected in 1962 were generally lower than those for the other years.

The data for the earlier years, up to 1965, have been compared previously with the data from Germany, England, and the U.S. Atomic Energy Commission in the 0-4 and 5-19 age groups (*3,6, 9-12*). The values are not dissimilar when allowing for differences in sampling techniques and geographic locations.

As in previous reports for 1962 to 1965 (*1-4*), the data were compared with Federal Radiation Council's (FRC) Radiation Protection Guides (RPG). FRC Report No. 2 (*13*) presents three ranges of radionuclide intake for guidance during normal peacetime operations. For strontium-90, the FRC Report stated that a continuous intake

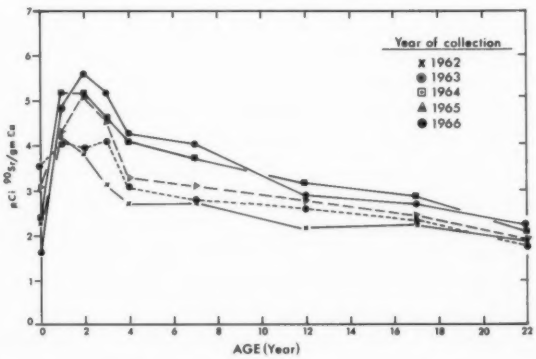

Figure 2. Plot of median strontium-90 to calcium ratio versus age by year of collection

of 200 pCi/day over a period of 1 year would correspond to ⅓ of the Radiation Protection Guide (0.17 rad/a) to mineral bone for a suitable sample of an exposed population. This would result in an average skeletal concentration in the exposed population of one-fourth of that in the diet (50 pCi/g Ca). The FRC Report No. 7 (*14*) presented a more detailed discussion on dosimetry considerations. It stated that 1 nCi of strontium-90/g of calcium in adult bone would result in a dose of 2.7 rad/a to the mineral bone. Therefore, the concentration corresponding to ⅓ of the RPG (0.17 rad/a) would be 63 pCi ^{90}Sr/g Ca. This report also states that dose to mineral bone of the fetus and infant may be one-half that of the adult value

Table 1. Strontium-90 in human bones by year of death and age in the United States

Age (years)	Strontium-90 to calcium ratio (pCi/g)				
	1962	1963	1964	1965	1966
0[a]	[b] 2.28(15)	1.64(5)	2.34(9)	3.08(23)	3.56(6)
	1.26–4.13	1.01–2.69	1.24–4.46	1.30–7.30	2.13–5.97
1	4.17(9)	4.83(4)	5.20(9)	4.32(12)	4.07(13)
	2.24–7.76	2.83–8.26	3.63–7.45	3.16–5.91	3.25–5.08
2	3.81(11)	5.60(9)	5.16(13)	5.14(19)	3.83(15)
	2.48–5.84	3.32–9.45	3.31–8.04	3.68–7.18	2.53–5.80
3	3.13(5)	5.14(11)	4.62(20)	4.56(15)	4.09(16)
	2.33–4.21	2.95–8.97	3.21–6.64	3.77–5.51	2.75–5.95
4	2.70(10)	4.25(15)	4.09(17)	3.24(14)	3.05(15)
	2.01–3.61	2.72–6.64	2.77–6.05	2.50–4.21	2.12–4.39
0–4	3.04(50)	4.28(44)	4.25(68)	3.94(83)	3.70(67)
	1.79–5.16	2.35–7.82	2.62–6.91	2.28–6.81	2.54–5.37
5–9	2.74(32)	4.00(42)	3.70(64)	3.06(56)	2.69(60)
	1.44–5.22	2.72–5.89	2.52–5.43	2.12–4.42	1.97–3.67
10–14	2.15(28)	2.86(46)	3.13(55)	2.75(53)	2.59(57)
	1.47–3.16	1.88–4.35	2.13–4.61	1.97–3.84	1.89–3.55
15–19	2.23(30)	2.65(74)	2.83(58)	2.39(64)	2.34(76)
	1.50–3.32	1.85–3.79	1.86–4.31	1.80–3.17	1.60–3.42
20–24	1.84(29)	2.19(61)	2.11(58)	1.84(69)	1.74(61)
	1.38–2.44	1.47–3.26	1.40–3.17	1.37–2.49	1.32–2.28

[a] Includes age group 0 to 5 months.
[b] Upper left number is the median. The number in parentheses indicates the number of samples. The lower numbers are the minimum and maximum values which embrace 68 percent of the samples in that group.

because of less mineral content and less absorption of available beta-particle energy, resulting in a concentration of 126 pCi/g Ca corresponding to 0.17 rad/a.

The highest single value measured for an individual in the 0-4 age group in 1962 was 10.8 pCi ^{90}Sr/g Ca. In 1963, the highest single value was 9.95 pCi ^{90}Sr/g Ca for this age group. The value was 14.6 pCi ^{90}Sr/g Ca for 1964. The values for 1965 and 1966 were 11.7 and 9.6 pCi ^{90}Sr/g Ca. These data for individuals, with the single exception in 1964, were within the guides corresponding to Range I. The average values within the five age groups for all years (1962-1966) also reveal that the Range I was not exceeded. Because of unavoidable deficienceis in the sampling programs, especially lack of samples in certain regions for some of the years, no definite inferences on population average values could be made.

The percentile distribution of the samples by strontium-90 to calcium ratio and year are as follows: In 1962, 84 percent of the samples analyzed contained 3.0 pCi ^{90}Sr/g Ca or less. In 1963, 85 percent of the samples were equal to or less than 4.0 pCi ^{90}Sr/g Ca, and in 1964, the 85 percent value had risen to 5.0 pCi ^{90}Sr/g Ca. The 85 percent value decreased in 1965 to 4.0 pCi ^{90}Sr/g Ca and decreased again to 3.5 pCi ^{90}Sr/g Ca in 1966. These data are in agreement with the previously observed trends. A log probability plot for the year 1966 is shown in figure 3 by age groups. These data are normally distributed as in previous years (*2-4*) and as originally reported by Kulp (*5*) for biological materials. Figure 4 shows a histogram of the frequency distribution for the year 1966, showing a slightly positive skewness.

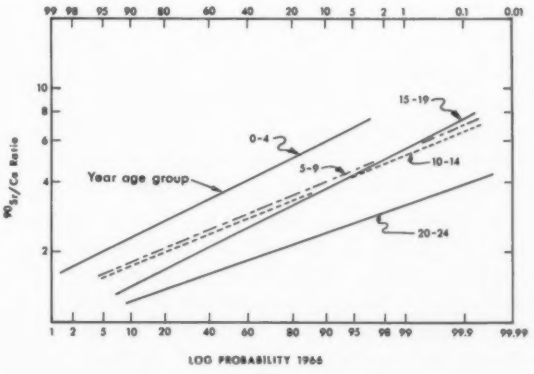

Figure 3. Log probability plot of strontium-90 to calcium ratios by age group for 1966

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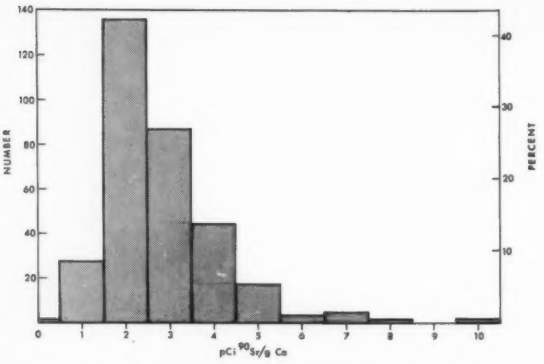

Figure 4. Frequency distribution strontium-90 to calcium ratios for 1966

Summary

From 1962 through 1966, over 1,600 human bone specimens were analyzed. The specimens are grouped and analyzed according to age and area of residence. A review of the data shows that peak strontium-90 levels occurred in most age groups during the years 1963 and 1964. The strontium-90 to calcium ratios began decreasing after 1964 and in 1966 approached those of 1962. A histogram of the frequency distribution for 1966 displays a slightly positive skewness which, when plotted, indicates a log normal distribution consistent with earlier observations on biological specimens.

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SECTION I. MILK AND FOOD

Milk Surveillance, December 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network, (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Foods, Pesticides and Product Safety, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service) - 5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare) - 16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively.) The contents of both

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Acknowledgement

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Health
Radiological and Occupational Health Section
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
California Diet Study	November 1967–September 1968	May 1969
Radionuclides in Institutional Diet Samples, *PHS*	April–June 1969	January 1970
Strontium-90 in Tri-City Diets, *HASL*	August–December 1968	December 1969
Connecticut Standard Diet	July–December 1968 and January–June 1969	February 1970

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3. Mexican Air Monitoring Program September and October 1969

National Commission of Nuclear Energy
México, D.F.

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency, 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*6*).

The maximum, minimum, and average beta radioactivity in surface air during September and October 1969 are presented in tables 3 and 4.

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, September 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	11	0.3	0.1	0.2
Ciudad Juarez	3	.2	.1	.1
Ensenada	5	.2	.1	.2
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	NS			
Mérida	15	.2	.1	.1
México, D.F.	10	.2	.1	.1
Nuevo Laredo	6	.3	.1	.2
San Luis Potosí	NS			
Tampico	NS			
Torreon	11	.2	.1	.1
Veracruz	2	.1	.1	.1

NS, no sample, station temporarily shutdown.

Table 4. Mexican gross beta radioactivity of airborne particulates, October 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	2	0.1	<0.1	<0.1
Chihuahua	16	.3	<.1	.2
Ciudad Juarez	3	.2	.1	.1
Ensenada	12	.5	.1	.2
Guadalajara	NS			
Guaymas	NS			
La Paz	1	.1	.1	.1
Matamoros	NS			
Mazatlan	NS			
Mérida	11	.2	.1	.1
México, D.F.	5	.1	<.1	<.1
Nuevo Laredo	7	.4	.2	.3
San Luis Potosí	NS			
Tampico	NS			
Torreón	17	.6	.1	.2
Veracruz	NS			

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program December 1969

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in in the January 1968 issue of *Radiological Health Data and Reports*. The December 1969 air monitoring results from the participating countries are given in table 5.

Table 5. Summary of gross beta radioactivity in Pan American surface air, December 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	21	0.16	0.05	0.09
Bolivia:	La Paz	10	.15	.01	.08
Chile:	Santiago	30	.17	.03	.09
Colombia:	Bogota	20	.05	.00	.02
Ecuador:	Cuenca	NS			
	Guayaquil	NS			
	Quito	1	.01	.01	.01
Guyana:	Georgetown	NS			
Jamaica:	Kingston	13	.11	.01	.06
Peru:	Lima	NS			
Venezuela:	Caracas	15	.10	.00	.03
West Indies:	Trinidad	16	.04	.01	.02
Pan American summary		126	0.17	0.00	0.06

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no sample.

Figure 5. Pan American Air Sampling Program stations

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Lawrence Radiation Laboratory, Neutron Devices Department, Paducah Plant, and Portsmouth Area Gaseous Diffusion Plant.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Radiation Laboratory[2] January–June 1969

University of California
Berkeley, Calif.

Berkeley site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is situated on the western slope of the range of hills running along the eastern side of San Francisco Bay. The laboratory area is largely separate from the main campus of the University, although there is some overlap (figure 1).

To the north and south of the laboratory area are residential areas of the cities of Berkeley and Oakland. The Berkeley campus of the University of California is on the west; to the east, are the Lawrence Hall of Science and the Space Sciences Laboratory, beyond them lies uninhabited watershed land and the Tilden Regional Park.

The most prevalent wind direction is westerly. During the summer months the afternoon sea breeze establishes a very pronounced prevailing westerly wind direction. At other times, the direction is less predictable. Annual rainfall is 23 inches, almost all of which falls between November 1 and May 1. The prevailing wind direction during precipitation is southerly.

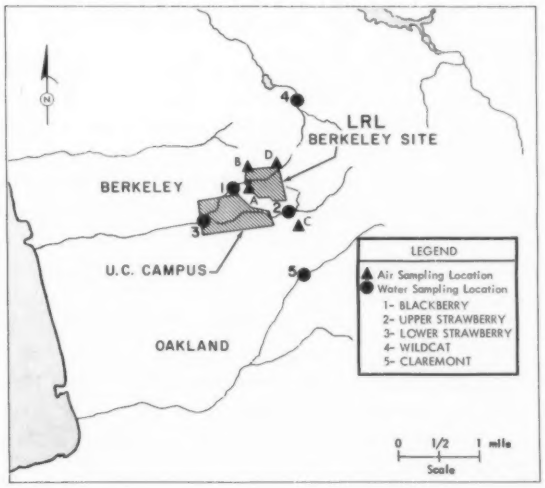

Figure 1. Environmental sampling locations at the Berkeley Site, Lawrence Radiation Laboratory

The laboratory carries on a wide ranging program of general research in the fields of both physical and biological sciences. Facilities include

[2] Summarized from "Results of Environmental Radioactivity Sampling Program, January–June 1969" Lawrence Radiation Laboratory, Livermore and Berkeley, Calif.

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a number of large accelerators, and various physics, chemistry, biology and medical research laboratories.

The basic policy at LRL has long been to prevent, as far as possible, any release of radioactive material to the environment, no matter how small. No deliberate releases are sanctioned, except where no practical method for containment has yet been developed and quantities are small compared with standards established by the ICRP and AEC.

The most sensitive measurements of releases are those taken closest to the source itself, before dilution makes detection of small quantities more difficult. The stack sampling program, therefore, provides the most useful information for controlling releases to the atmosphere. Over 100 separate exhausts from hoods and glove-box manifolds are sampled. The total quantity released from these stacks during January-June 1969 was 64 μCi of beta-particle emitters. No alpha radioactivity was detected. The average concentrations in the total exhaust, before any dilution by the atmosphere, was 1 percent of the maximum permissible concentration for offsite breathing zone air, as given by the ICRP.

In addition to the careful sampling of stacks, an environmental air sampling program is also carried on to make sure no undetected releases occur. These samples provide a direct measurement of possible exposure to the nearby population. The sampling stations designated "local area" are scattered around the site and provide samples of the atmosphere on the site itself. The "perimeter" samples are taken at the boundary line of University property in the direction of populated area. From the results of these samples, it is apparent that there has been no significant exposure from radioactive materials released by LRL. The levels of radioactivity observed in each type of sample are presented in table 1.

Table 1. Atmospheric monitoring, LRL Berkeley Site January–June 1969

Sampling locations (number of locations)	Number of samples	Average concenrration (pCi/m³)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Local area (10)	253	0.000	<0.005	0.14	0.62
Perimeter (4)	100	.000	<.005	.14	.47

At each of these environmental stations rain or dry fallout is also collected. Open 15-inch diameter polyethylene bags form the collecting vessel. If no rain has fallen, the bags are rinsed out with dilute nitric acid. Results from these collections show a lot of variation, without any consistent pattern. Since on the average, the more remote perimeter stations show about the same radioactivity as the nearer ones, it must be assumed that the radioactivity does not result from laboratory operations. The radioactivity levels in samples collected at each location are summarized in table 2.

Table 2. Total deposition, LRL Berkeley Site January–June 1969

Sampling locations (number of locations)	Number of samples	Average concentration (pCi/m²)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Local area (9)	54	0.03	0.08	9.57	11.31
Perimeter (4)	24	.06	.22	8.92	10.77

All liquid waste known to be radioactive is collected, solidified, and shipped away. Other liquid wastes are discharged directly to the municipal sewer system. Small quantities of radioisotopes now and then are accidentally released to the sewer system. There are two outfalls, each of which is monitored by a continuous proportional sampling system to insure that no significant quantities have been discharged. The total concentration (alpha-plus-beta radioactivity) in sewage is only 16 percent of the standard for drinking water and therefore does not constitute an exposure threat. A sizeable fraction of the measured beta concentration is the naturally occurring isotope potassium–40 from human wastes and chemicals.

The storm drainage from the laboratory flows into the surface stream system. These surface streams are exposed as they run through the University property and are sampled at three places. Results are listed as "onsite streams" in table 3. Two nearby offsite streams are also sampled to provide a comparison. All concentrations are safely below the standard for drinking water. The results from the water sampling program are presented in table 3.

Neutron and gamma-ray fields are measured at each of the four perimeter stations as well as at

Table 3. Water monitoring, LRL Berkeley site January–June 1969

Type and source of sample	Number of samples	Concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Surface water:					
Onsite streams					
Blackberry	26	0.35	2.2	4.60	41.3
Lower Strawberry	26	.45	1.8	10.66	30.2
Upper Strawberry	26	.29	3.5	3.37	9.0
Summary	78	.36		6.21	
Offsite streams:					
Claremont	26	.58	1.4	2.82	16.3
Wildcat	26	.00	1.6	2.23	9.6
Summary	52	.29		2.52	

several locations within the site. Background measurements are obtained from a leased building used as a low-level counting room in downtown Berkeley. This building is remote from the main LRL site and measurements are not influenced by accelerator operations.

At each station, gamma measurements are made by a recording G-M detector, standardized with a calibrated radium source. These instruments operate unattended and each can operate for 1 week on its internal battery should external power fail.

Table 4. Beta-gamma and fast neutron surveillance results, Berkeley site, January 1968–June 1969

Station	Total beta-gamma exposure (mrem) (background subtracted)			Total fast neutron exposure[a] (mrem) (background subtracted)		
	Jan–June 1968	July–Dec 1968	Jan–June 1969	Jan–June 1968	July–Dec 1968	Jan–June 1969
A	12.7	5.72	10.9	56.7	56.4	38.89
B	6.1	[b]	4.4	21.4	30.5	26.42
C	8.0	[b]	[b]	4.4	34.5	[b]
D	4.5	1.12	6.1	46.0	53.5	55.67
Shattuck Avenue and Berkeley Way	0.2	[c]	[c]	[c]	[b]	[b]

[a] 2.45×10^7 n/cm² = 1 rem
[b] Background.
[c] Detector not in service.

Several neutron detectors are employed at each station. The primary detector is a BF_3 gas proportional counter in a 2 1/2 inch thick paraffin lined moderator. This detector is sensitive in the region from 0.1 to 20 MeV, where 75 percent of the biologically significant neutrons exist. A polyethylene-lined proton recoil neutron detector provides a measure of the energy flux density. The ratio of energy flux density to neutron flux density gives the average neutron energy which allows conversion of the data to dose in rems. Cobalt disks in moderators are maintained as long term integrating neutron monitors at many sites throughout the laboratory as well as at each perimeter station.

Cosmic ray intensity is continuously monitored by a meson detector with an effective angle of acceptance of 2.3 steradians (in the upward direction). This provides information on the background neutron levels contributed by cosmic rays. Results are presented in table 4.

Livermore site

The Livermore site of LRL (figure 2) is located in the Livermore Valley midway between the Pacific coast and the San Joaquin Valley in northern California--approximately 50 miles southeast of San Francisco. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Annual rainfall is about 14 inches and the relative humidity is about 30 percent during the summer months and about 40–50 percent the remainder of the year. Prevailing winds are from the west, but inversions are frequent during the night.

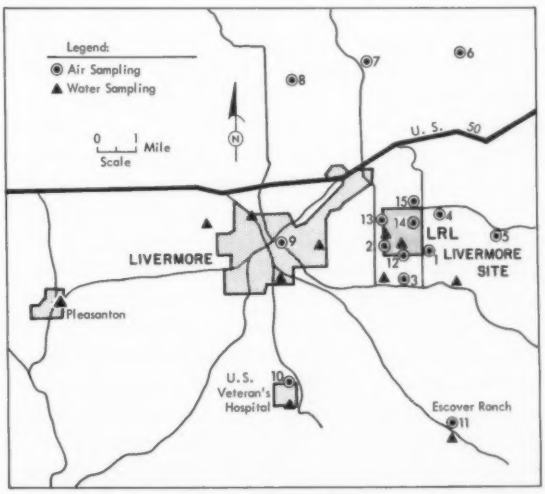

Figure 2. Environmental sampling locations at the Livermore site, LRL

Agriculture is the principle activity in the Livermore Valley. Roses, grain, hay, and grapes are the major products. Several cattle and sheep ranches surround the Livermore site.

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The Livermore site comprises an area of 1-square mile, approximately 3 miles east of the city of Livermore. Livermore and Pleasanton, with a combined population of 50,000 are populated areas of primary interest to the Livermore site.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, sewage plant products, milk, and vegetation. The milk samples are obtained from one dairy in the Livermore Valley and from another dairy near Site 300. Air and soil samples are collected to ascertain that control efforts are restricting the release of radioactivity from the laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to ascertain that radioactivity is not entering the underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton and is the sole supply for ranches in the Livermore and Amador Valleys. Samples were taken at the Livermore Sewage Disposal Plant to establish that liquid effluent from the laboratory is not contributing significant radioactivity to the dried sludge or liquid effluent produced. The dried sludge is used as an agricultural soil conditioner. Some liquid effluent released to the Las Positas Arroyo is used for irrigation of the golf course turf and some agricultural land.

Air samples are collected continuously at 16 sites within 5 miles of the laboratory. Samples are collected at a rate of 4 cfm on 100-square centimeter HV-70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. At no time was any detectable alpha radioactivity observed on the air filters. The average airborne beta radioactivity of 0.06 pCi/m^3 is lower than the 0.1 pCi/m^3 reported for 1968 .The beta radioactivities were below the AEC radiation protection standard of 1 pCi/m^3.

The measurement of low level "background" radiation during this period was accomplished with thermoluminescent dosimeters located at nine points on the site perimeter and at three offsite locations. The limit of detection for these dosimeters is 10 mR. The three offsite locations had dose recordings of 10 mR for the past 6-month period. At the nine locations in the controlled area, doses of 10 to 54 mR were recorded.

Domestic water samples were collected monthly from nine nearby sources. No sample showed an alpha specific radioactivity above the limit of detection (5.0 pCi/liter). The beta radioactivity fluctuated from the limit of detection, 1.8 pCi/liter to 31 pCi/liter. The average beta radioactivity concentration was 6.5 pCi/liter. The average alpha and beta radioactivity concentrations were below the AEC standard of comparison of 30 pCi/liter.

The average tritium content was at or below the limit of detection (5 nCi/liter), which is well below the standard of comparison of 3 μCi/liter.

Samples were collected daily at the laboratory sewer discharge. The average alpha radioactivity concentration in the sewer effluent ranged between 8 and 19 pCi/liter while the monthly average beta radioactivity varied between 146 and 213 pCi/liter. The AEC standard is 400 pCi/liter. The average tritium content of the effluent was 35 nCi/liter with a maximum of 950 nCi/liter. The AEC standard is 100 μCi/liter.

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha radioactivity of each sample was less than the limit of detection (1.5 pCi/g). The beta radioactivity fluctuated from the limit of detection, 3.5 pCi/g to 27 pCi/g, averaging 6.8 pCi/g. The concentrations detected are within the normal range for soil in the Livermore Valley, as determined from surveillance during previous years.

Average radioactivity levels in monthly milk samples amounted to 1.8 pCi/liter of cesium-137 and <5 pCi/liter of cerium-141–144, for the two dairies. The average tritium concentration in milk was at or below the limit of detection (5 nCi/liter).

Vegetation samples were collected during January, March, and May of 1969. The radioactivity of 23 unwashed grass samples and six samples of eucalyptus leaves is presented in table 5. A portion of each sample was freeze dried and the water collected was analyzed for HTO.

Continuous radioactive air sampling is maintained on the effluent from stacks of operations

Table 5. Radioactivity in vegetation, LRL Livermore site January–June 1969

Nuclide	Concentration (pCi/g dry weight)				Limit of detection
	Grass		Eucalyptus leaves		
	Average	Maximum	Average	Maximum	
Beryllium-7	3.28	8.34	0.82	0.89	0.01
Manganese-54	.02	.03	.02	.03	.01
Zirconium-95	.34	.54	.13	.13	.01
Ruthenium-103, -106	.56	1.04	.28	.44	.02
Antimony-125	.11	.21	.17	.30	.02
Cesium-137	.15	.33	.01	.01	.01
Cerium-141, -144	1.70	3.17	.96	1.41	.02
Tritium	[a] 3.5	[a] 21	[a] 11	[a] 24	[a] 5

[a] Concentration for tritium values are shown in nCi/liter.

that are potential sources of radioactive material releases. These facilities include the hot cells, transuranic chemistry, plutonium metallurgy, critical assembly cells, and the reactor building.

The effluent from these buildings passes through absolute filters prior to being exhausted to the atmosphere. The limit of sensitivity for the stack monitoring systems is generally 0.1 pCi/m³ or less. Radioactive particulate material released did not exceed the limit of sensitivity. Gaseous radioactivity released from the reactor, light isotopes building and accelerator facilities was monitored. Considering atmospheric dispersion from the release point to the site boundary, permissible offsite concentrations were not exceeded as a result of stack effluent during the past 6 months.

Site 300

The high explosive test area at Site 300 (figure 3) covers 10 square miles in the hills in a very sparsely populated ranching area about 15 miles southeast of Livermore and 8 miles southwest of Tracy. The chief area of concern for Site 300 is Tracy. The population there is about 14,000. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on regular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from onsite wells because they are the only readily accessible sources of underground water. Streams in the area are sampled when they contain water. No sample showed an alpha radioactivity concentration above the limit of detection—5.0 pCi/liter. The beta concentration ranged from the limit of detection (1.8 pCi/liter) to 20 pCi/liter, averaging 6.0 pCi/liter. The average tritium concentration was at or below the detectable level of 5 nCi/liter.

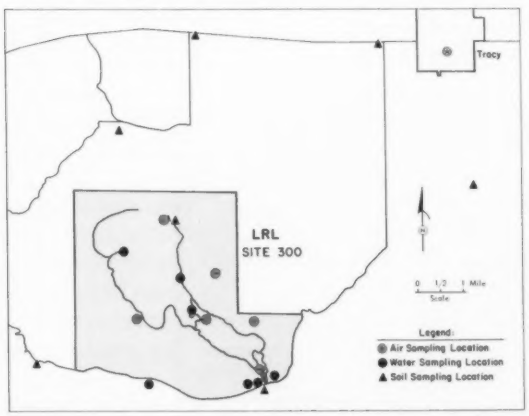

Figure 3. Sampling locations at Site 300, LRL

Soil samples are collected quarterly at nine offsite locations. The alpha radioactivity of each sample was 1.5 pCi/g, the limit of detection. The beta radioactivity ranged from the limit of detection, 3.5 pCi/g to 27 pCi/g, with an average activity of 8.8 pCi/g.

None of the average concentrations of air, water, and soil samples exceeded the standards of comparison applicable to activities at the test site, nor did any of the results increase significantly compared to 1968 data. Therefore, it appears that radiological control measures at Site 300 were adequate and that no significant radioactivity was released to the environment near the site during this period.

XUM

2. Neutron Devices Department[3] January–June 1969

General Electric Company
St. Petersburg, Fla.

The Neutron Devices Department (figure 4) is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plant's contamination control measures. Effluent radioactivity concentrations and associated atmospheric and stream dilution factors indicate that offsite radioactivity concentrations encountered by the general population are substantially lower than the guides for continuous nonoccupational exposure established by AEC and documented in the "AEC Manual."

[3] Summarized from "Environmental Monitoring, January 1 through June 30, 1969" General Electric Company, Neutron Devices Department, St. Petersburg, Fla.

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period, eight of 283 samples analyzed showed detectable concentrations of tritium (>90 nCi/liter). The maximum concentration (1.58 μCi/liter, detected on February 10, 1969) represented 53 percent of the continuous nonoccupational exposure guide. Calculations based on radioactivity releases from the process waste system and the plant's water discharges indicate that the tritium concentration in the combined sewer effluent for the first half of 1969 was less than 3.7 percent of the AEC radiation protection standard for continuous nonoccupational exposure.

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data.

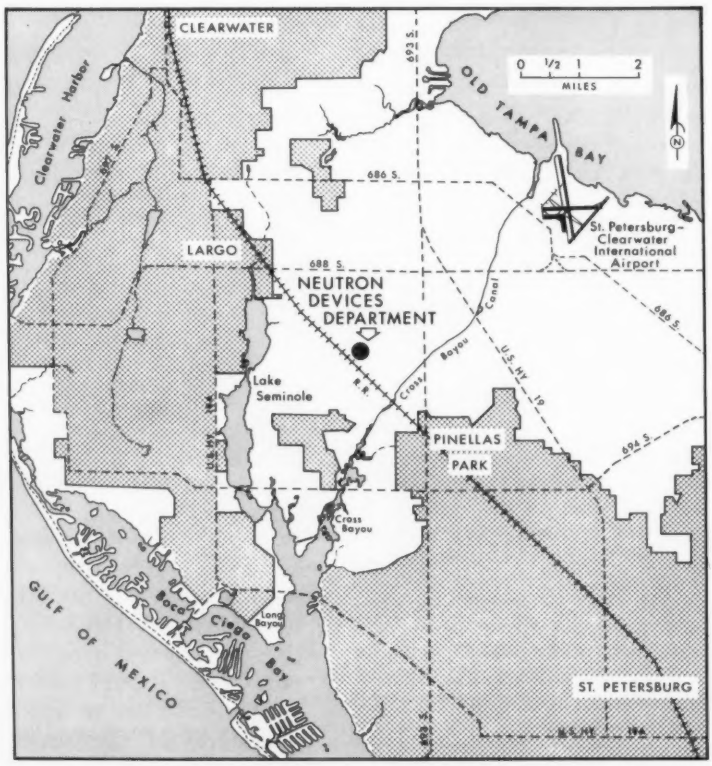

Figure 4. Location of the Neutron Devices Department

There were no indications of tritium (>90 nCi/liter) in the 67 surface water samples analyzed during the sampling period.

Milk sampling results

Analyses of 12 raw milk samples, collected from one local dairy farm by the Pinellas County Health Department, revealed no detectable concentrations (>90 nCi/liter) of tritium.

Air sampling results

No detectable amount of tritium gas (>20 μCi/m^3) was found in three samples of air obtained downwind from the exhaust stack at the perimeter of the plant property. No detectable amount of tritium oxide (>5.0 nCi/m^3) was found in four samples of air obtained downwind from the exhaust stack at the perimeter of the plant property.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	December 1969
July–December 1968	January 1970

3. Paducah Plant[4] January–June 1969

Union Carbide Corporation
Paducah, Ky.

The Paducah Plant is a government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. The uranium hexafluoride manufacturing plant, a former source of diffusion plant feed, was placed on standby in June of 1964. Parts of the associated uranium metal foundry, usually on standby, are operated infrequently as the need arises. A decontamination and uranium recovery facility operates to prepare equipment for repair and to recover impure or scrap uranium materials. Depleted uranium metal is fabricated into shields, weights, ballasts, or other shapes on a nonroutine basis. The major sources of external penetrating radiation are the daughter products of uranium, thorium-234 and protactinium-234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

Because of the necessity for health protection in process areas, the high intrinsic value of uranium, and the desire to maintain a wholesome relationship with neighboring communities and individuals, the Paducah Plant provides confinement and recovery systems at the plant. The environmental monitoring program provides for continuous air sampling at the four stations around the plant perimeter fence and at five stations located approximately 1 mile outside this fence (figure 5). Big Bayou Creek water is sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma radiation readings are taken each month at each of the air sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

Basic standards

The radiation protection standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employees and for offsite exposure of the general population, are those contained in Appendix 0524 of the AEC manual.

The standards specify that the radiation or radioactive materials outside a controlled area, and which have resulted from operations within that controlled area, shall be such that it is improbable that any individual may receive a dose

[4] Summarized from "Environmental Concentrations of Radioactive Materials Near the Paducah Plant—Report for the First Half of 1969."

XUM

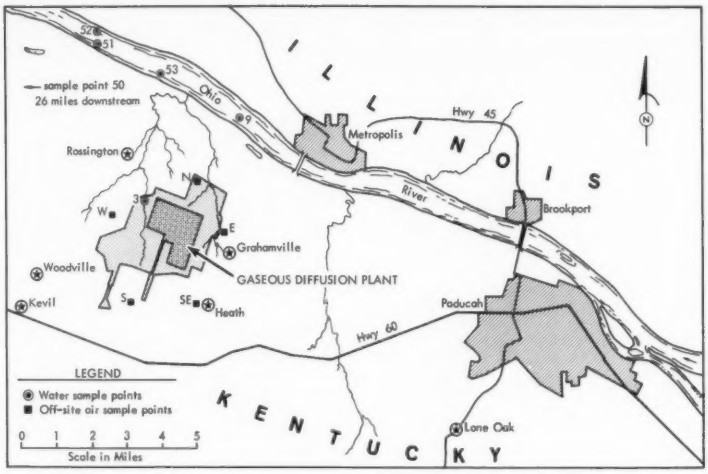

Figure 5. Sampling locations, Paducah Gaseous Diffusion Plant

of external radiation greater than 0.5 rem in any year and that the average exposure of a suitable population sample may not exceed one-third of this dose. To meet this standard, the average concentration of radionuclides in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

Table 6. Uranium concentrations in outdoor air samples, Paducah Plant, January–June 1969

Sample location[a]	Number of samples	Uranium alpha radioactivity[b] (pCi/m³)		
		Maximum	Minimum[c]	Mean[d]
At plant perimeter fence:				
North	26	0.24	<0.02	0.04
East	26	.17	<.02	.04
South	26	.05	<.02	<.02
West	26	.05	<.02	<.02
Total	104	0.24	<0.02	0.03
About 1 mile outside plant perimeter fence:				
North	26	0.02	<.02	<.02
East	26	.03	<.02	<.02
South	26	.06	<.02	<.02
West	26	.06	<.02	<.02
Southeast	26	.09	<.02	<.02
Total	130	0.09	<0.02	<0.02

[a] See figure 5.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 by 10^4 alpha dis/sec.
[c] The minimum detectable concentration of uranium in air is 0.02 pCi/m³.
[d] The AEC standard for natural uranium in air released to the environs beyond a controlled area is 2 pCi/m³.

Discussion

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 6 through 10.

Table 7. Beta radioactivity in outdoor air samples Paducah Plant, January–June 1969

Sample locations[a]	Number of samples	Beta radioactivity (pCi/m³)		
		Maximum	Minimum[b]	Mean[c]
At plant perimeter fence:				
North	26	5.4	<0.1	2.2
East	26	5.9	.2	.6
South	26	.9	<.1	.3
West	26	2.8	.1	.5
Total	104	5.9	<0.1	1.1
About 1 mile outside plant perimeter fence:				
North	26	.9	<.1	.3
East	26	.5	<.1	.2
South	26	.5	<.1	.3
West	26	.7	<.1	.2
Southeast	26	1.0	<.1	.2
Total	130	1.0	<.1	.2

[a] See figure 5.
[b] The minimum detectable amount of beta-particle emitters in air is 0.1 pCi/m³.
[c] The AEC standard, applicable to this table is 1×10^3 pCi/m³, which is the concentration limit of thorium-234, the daughter product of uranium-238. Insignificant amounts of other daughters are present in freshly refined uranium.

Air samples were collected continuously at each of the four stations at the plant perimeter fence and at five stations about 1 mile outside the plant.

Table 8. Concentrations of uranium in water Paducah Plant, January–June 1969

Sample location[a]	Number of samples	Uranium[b] (pCi/liter)		
		Maximum	Minimum[c]	Mean[d]
Big Bayou Creek 3	26	20	<1	6
Ohio River 9	5	1	<1	<1
Composite of 50, 51, 52, and 53	5	<1	<1	<1

[a] See figure 5.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 dis/sec.
[c] The minimum detectable uranium in water is 1 pCi/liter.
[d] The AEC standard for natural uranium in water beyond a controlled area is 2×10^4 pCi/liter.

Table 9. Concentration of beta-particle emitters in water, Paducah Plant, January–June 1969

Sample locations[a]	Number of samples	Beta-particle emitters (pCi/liter)		
		Maximum	Minimum[b]	Mean[c]
Big Bayou Creek 3	26	12,000	<100	900
Ohio River 9	5	200	<100	<100
Composite of 50, 51, 52, and 53	5	<100	<100	<100

[a] See figure 5.
[b] The minimum detectable amount of beta-particle emitters in water is 100 pCi/liter.
[c] The AEC standard for the immediate daughter products of uranium in water released to the environs is 2×10^4 pCi/liter. An increase in beta activity in water, occurring during February and March, was determined to be due to ^{99}Tc from the recovery operation of cylinder-wash solutions. The AEC standard for ^{99}Tc in water beyond a controlled area is 2×10^3 pCi/liter.

Air is filtered at 0.3 cfm through 2-inch diameter membrane filters which are replaced weekly and counted for alpha and beta radioactivity.

The average alpha-particle count—interpreted as uranium, the most likely source of radioactivity—of the 104 and the 130 air samples collected during the first half of 1969 at the perimeter fence and 1 mile, respectively, were 1.5 percent and less than 1 percent of the AEC standard set for individuals residing in the vicinity of a controlled area. The average beta-particle count of these samples was 0.11 percent of the standard at the perimeter fence and 0.03 percent of the standard at 1 mile.

Table 10. External gamma radiation levels, January–June 1969

Sample locations[a]	Number of readings	Gamma radiation (mR/h)
At plant perimeter fence		
North	5	0.02
East	5	[b].04
South	5	.02
West	5	.02
Total	20	0.02
About 1 mile outside plant perimeter fence		
North	5	0.02
East	5	.02
South	5	.02
West	5	.02
Southeast	5	.02
Total	25	0.02

[a] See figure 5.
[b] Near uranium hexafluoride cylinder storage area.

The average uranium analyses of weekly water samples collected continuously from the Big Bayou Creek during January–June 1969 was 0.03 percent of the AEC standard for water beyond a controlled area. The results of the uranium analyses for each of the 5 grab samples collected at monthly intervals from the Ohio River below the plant were less than 0.01 percent of the AEC standard.

The concentration of beta-particle emitters in the Big Bayou Creek averaged 4.5 percent of the AEC standard for the decay products of uranium-238. The beta radioactivity of the Ohio River was less than 0.5 percent of the standard for uranium-238 decay products.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/h at all sampling stations for January–June 1969, except for the east plant perimeter station which had an average of 0.04 mR/h.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
January–December 1968	October 1969

XUM

4. Portsmouth Area Gaseous Diffusion Plant[5] January–June 1969

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. To verify the effectiveness of plant controls, environmental monitoring is conducted for evidence of alpha-particle, beta-particle, and gamma-ray emitters.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 6. Monthly water samples are collected at 13 stations within 5 miles of the plant.

For January–June 1969, the waterborne alpha and beta-gamma radioactivity decreased over the calendar year 1968. The airborne alpha and beta-gamma remained essentially unchanged.

Penetrating background dose rates for the first half of 1969 were considerably lower when compared with the calendar year 1968 values. In the calculations, it is assumed that all of the dose rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities, it is evident that the plant operations have not added appreciably to the general background radiation.

Average alpha and beta-gamma radioactivity concentrations in air and water are summarized in table 11. The external beta-gamma radiation

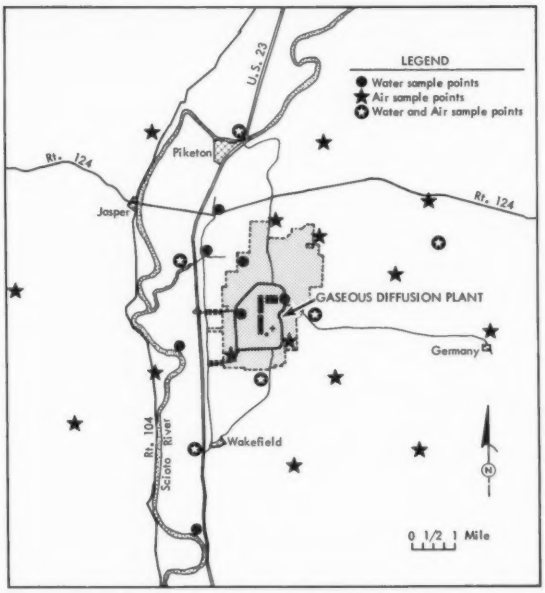

Figure 6. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

[5] Data summarized from B. Kalman and S. H. Hulett, "Environmental Radiation Levels and Concentrations, First Half 1969" (August 27, 1969).

Table 11. Environmental radioactivity, Portsmouth Plant January–June 1969

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent standard[a]
Air:					
Alpha radioactivity, (pCi/m³)	126	0.9	0.1	0.1	5.0
Beta-gamma radioactivity, (pCi/m³)	126	2.2	.1	.2	.02
Water:					
Alpha radioactivity, (pCi/liter)	74	486	.5	39.8	.02
Beta-gamma radioactivity, (pCi/liter)	73	1,620	14	75.7	.38
Background exposure[b] (mrem/h)	122	.015	.009	.012	13.5

[a] The applicable radiation protection standards are as follows:

Air (alpha radioactivity)	2 pCi/m³
Air (beta-gamma radioactivity)	1 nCi/m³
Water (alpha radioactivity)	20 nCi/liter
External (beta-gamma radioactivity)	0.5 rem/a (approx. 0.6 mrad/h)

[b] Measurements were made with an open-shield Geiger–Mueller 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the concentration standard.

levels, measured at the air sampling locations shown in figure 6, are also summarized in table 11. The overall average concentrations and background exposure rates for 1968 and January–June 1969 are presented in table 12 as percent of standards.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	January 1969
July–December 1968	November 1969

Table 12. Comparison of average concentrations Portsmouth, 1968–1969

Type of monitoring	Percent of AEC standard[a]			
	January–June 1968	July–December 1968	Calendar year 1968	January–June 1969
Air:				
Alpha radioactivity	<5.0	5.2	<5.0	<5.0
Beta-gamma radioactivity	.02	.03	.02	.02
Water:				
Alpha radioactivity	.13	.38	.28	.02
Beta-gamma radioactivity	.27	.55	.43	.38
Background exposure extrapolated to 3 feet above ground level	16.2	19.9	18.3	13.5

[a] See footnote (a) of table 11.

Reported Nuclear Detonations, March 1970

(Includes seismic signals from foreign test areas)

During March 1970, five United States nuclear tests at the Nevada Test Site were announced by the Atomic Energy Commission. Two low yield tests (less than 20 kilotons TNT equivalent) were conducted underground on March 6 and one test on March 19, 1970. A nuclear test in the low-intermediate yield range (20 to 200 kilotons of TNT equivalent) was conducted March 23, 1970. An underground nuclear test with an estimated yield of more than a megaton was conducted March 26, 1970, in the Pahute Mesa area of the Atomic Energy Commission's Nevada Test Site at 11 a.m., P.s.t. The test, assigned the name of Handley, was approximately the same size as the Boxcar and Benham tests in 1968, the largest tests previously conducted at the test site.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip then for their files.

AN INVESTIGATION OF X RADIATION FROM COLOR TELEVISION RECEIVERS IN SUFFOLK COUNTY, NEW YORK. *Seymour Becker. Radiological Health Data and Reports, Vol. 11, April 1970,* pp. 179–182.

The results of an investigation of color television receivers at the homes of 6,482 residents in Suffolk County, who requested a radiation inspection after publication of the proposed study in the newspapers, is presented.

The survey consisted of two parts:

1. an investigation of only General Electric color television sets from July 1967 through August 1967; and
2. a radiation inspection of General Electric and 39 other types of television receiver requested by owners from January 1968 to December 1969.

X-radiation emissions were detected in 37 of the 40 name brands of color television sets checked. Over 1,000 (16.2 percent) color television sets emitted x radiation above the NCRP recommended guides. The x-ray emissions ranged above 0.5 mR/h to 150 mR/h at 5 cm from the television set.

X-radiation emissions were reduced to the natural background of the home by adequate modification and adjustment of the television components.

KEYWORDS: Color television receivers, county, New York State, survey, x radiation

STRONTIUM–90 IN HUMAN BONES IN THE UNITED STATES, 1962–1966. *E. J. Baratta, E. S. Ferri,* and *M. A. Wall. Radiological Health Data and Reports, Vol. 11 April 1970,* pp. 183–186.

The Bureau of Radiological Health has been conducting a continuous investigation of strontium–90 in human bones since late 1961. Autopsy specimens, mostly vertebrae, are collected by pathologists, medical examiners, and coroners in selected areas throughout the United States. The population of interest consists of children and young adults up to 25 years of age. Samples were collected from areas around six principal cities: Atlanta, Boston, Cincinnati, Los Angeles, New Orleans, and Seattle.

From 1962 through 1966, over 1,600 specimens have been analyzed. The specimens are grouped and analyzed according to age and area of residence. A review of the data shows that peak strontium–90 levels occurred in most age groups during the years 1963 and 1964. Decreasing values are shown in analyses for 1966 approaching those of 1962. A histogram of the frequency distribution for 1966 displays a slightly positive skewness which, when plotted, indicates a log normal distribution consistent with earlier observations on biological specimens.

KEYWORDS: Bone, human, strontium-90, United States

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Abstracts: Manuscripts should include a 100- to 150-word abstract which is a factual (not descriptive) summary of the work. It should clearly and concisely state the purpose of the investigation, methods, results and conclusions. Findings that can be stated clearly and simply should be given rather than to state that results were obtained.

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